Homestake Massive Detector & Long Range Neutrino Oscillation Program

1) Introduction – Ken Lande
2) Long Base Line Neutrino Oscillations – Milind Diwan
3) 100 Kiloton Chamber Excavation – Mark Laurenti
4) 100 Kiloton Excavation Geophysics – Chris Laughton
5) Fermilab to Homestake Neutrino Beam – Bill Foster
6) Liquid Argon Detector – K. Lee/H. Wang
7) UNO & Water Cerenkov R & D Issues- Bob Wilson
8) Strategy for DUSEL υ Oscillation Program–Tom Kirk

The Goals

- Measure all neutrino oscillation parameters – search for CP violating terms
- Look for nucleon decay to 10^{35} years
- Search for υ bursts from SN throughout our Galaxy & possibly in Andromeda
- Continue investigation of oscillations of neutrinos produced in atmosphere by H.E. cosmic rays
- Provide an active veto shield for very low background devices

The Plan

Construct a Set of 100 kiloton water Cerenkov Detectors

Each 50 meters diameter by 50 meters high

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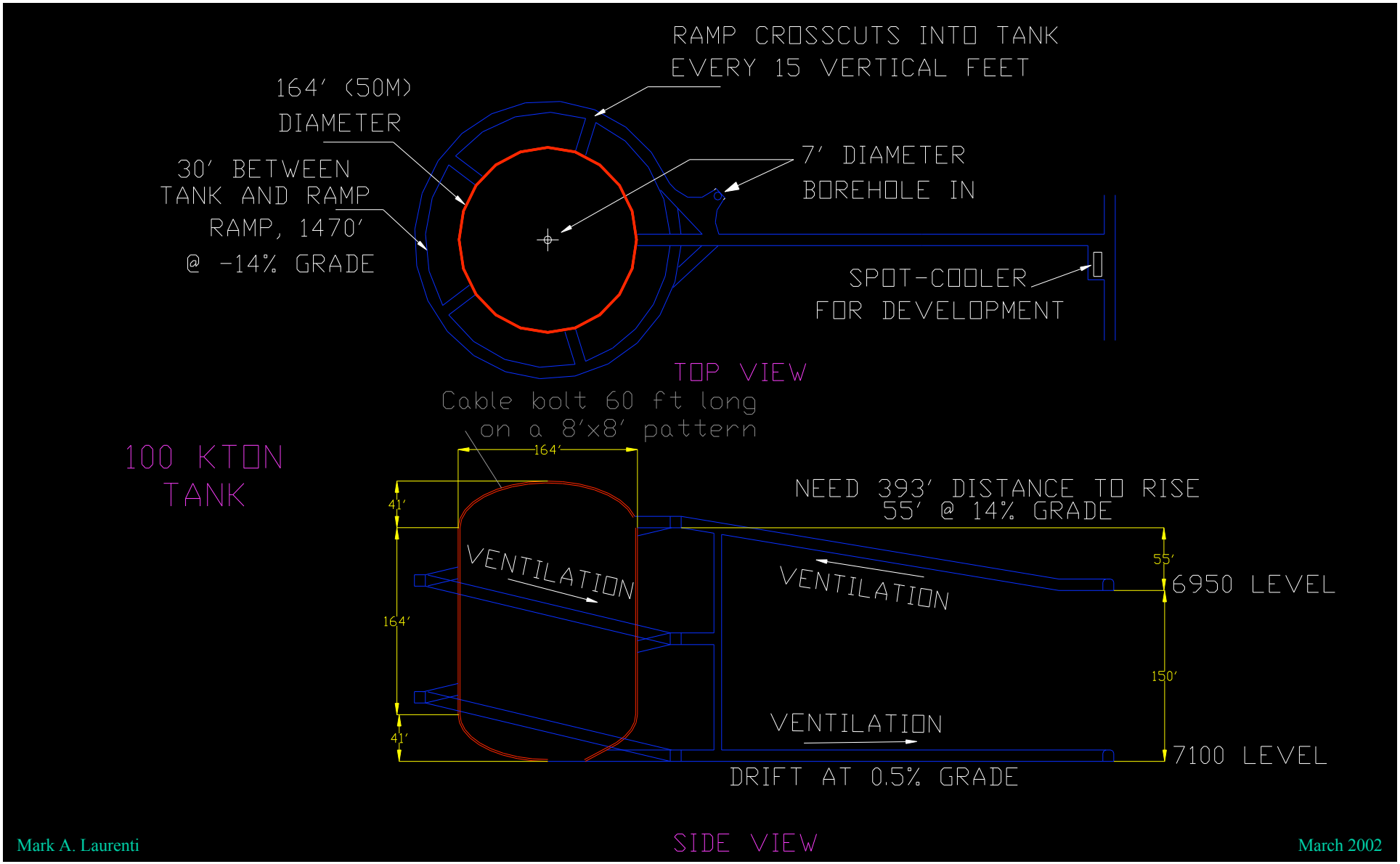
total mass ~1/2 - one megaton

Begin construction of first 100 kiloton detector –2007

Begin construction of the next 3 detectors –2009

100 Kiloton Module



The Cost/per module

Excavation (including water liner)	--$20 million
Photomultipliers (25% coverage) and electronics--	$25 million
Water purification & handling	$1 million
Miscellaneous	$5 million
Contingency – (30%)	$16 million
TOTAL	$67 million

The Site

The 4850 ft level at Homestake – site of the Chlorine solar neutrino detector

Cosmic ray muon flux – 4 muons/m^2, day

Or ~8000 C.R. muons/day/100 kiloton module

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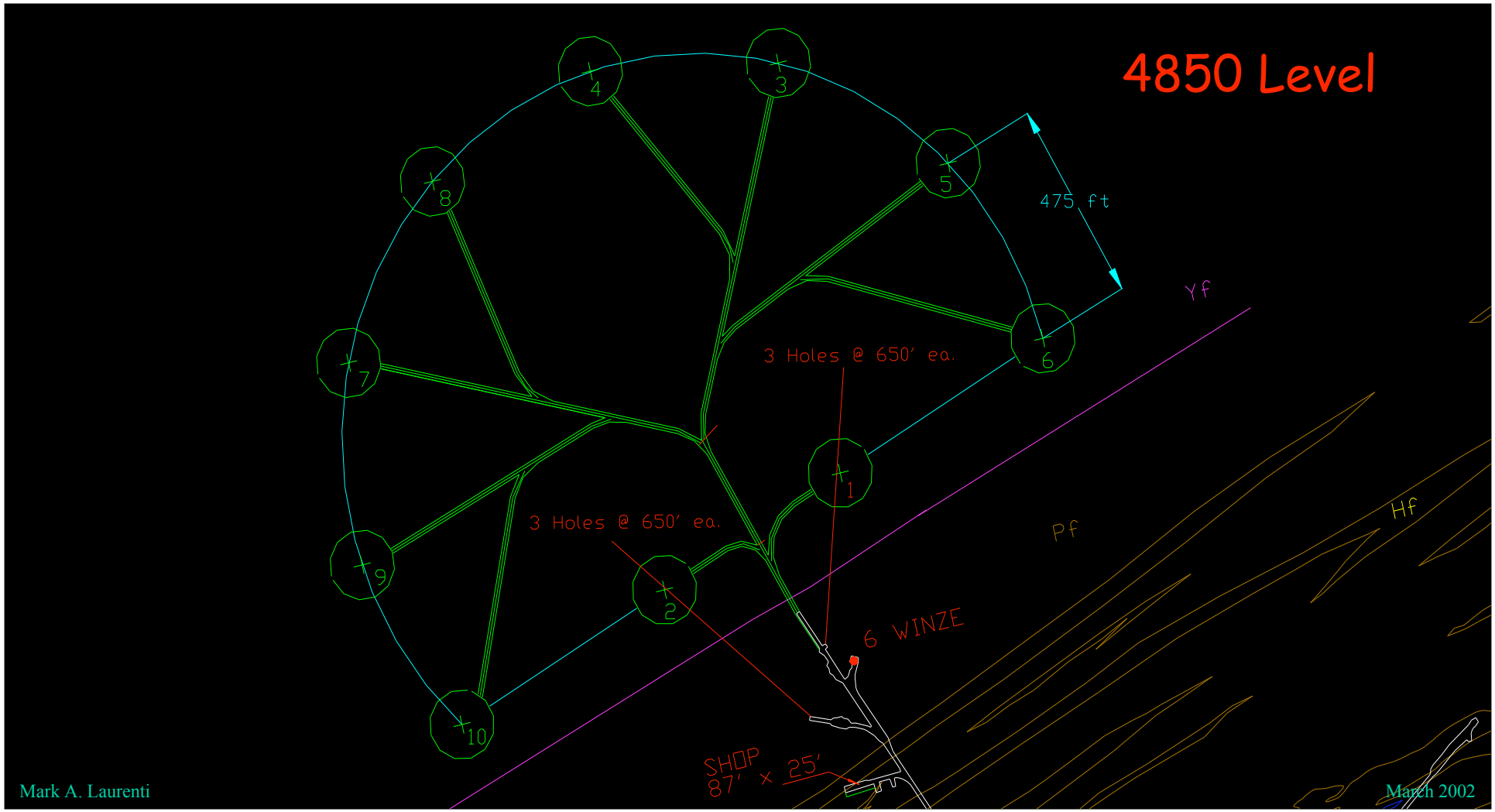
_ beam on time ~ μsec/sec or 10^{-1} sec/day

Result-

8 x 10^{-3} cosmic ray muons/day in detector during _ beam "on time"

Array of 100 Kiloton Detectors



Features of the Design:

1) Module dimensions 50 m diameter x 50 m high
- 100 kilotons water

2) Parallel construction of modules – one "crew" can build 3 modules in parallel- completion in 4-5 years

3) Concrete liner in each module provides strength and stability, smooth surface for water tight plastic inner liner, surface for photomultiplier installation guides.

5) Low construction cost

Water Containment:

1) A layer of polyurethane on the concrete liner.
2) A double plastic liner – a geotextile layer against the polyurethane followed by a fused polyethylene liner.

Photomultiplier Installation:

Side pms slide down along vertical guides- can be installed or removed without draining water, easy to vary pm density, guides provide “cushioned” mount in case of intense shock waves in water.

Top pms mounted under top platform– direct access

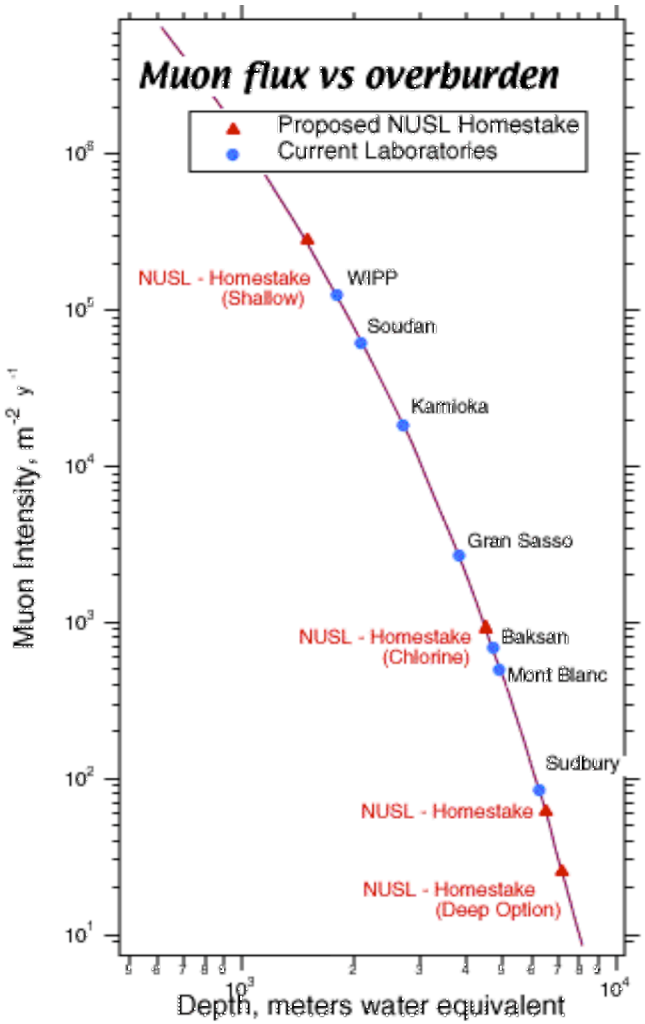
Bottom pms mounted on neutral buoyancy frame that can be raised to the top platform for access.

Detector Depth:

Greater depth gives lower background - we set a goal of **less than one cosmic ray background event per year per module** during the time window, ~1μsec/sec, when the neutrino beam from Fermilab is on target.

The detector depth, **4850 ft**, is far greater and detector background is far less than that at any other long range neutrino beam detector (Kamiokande, MINOS, Gran Sasso).

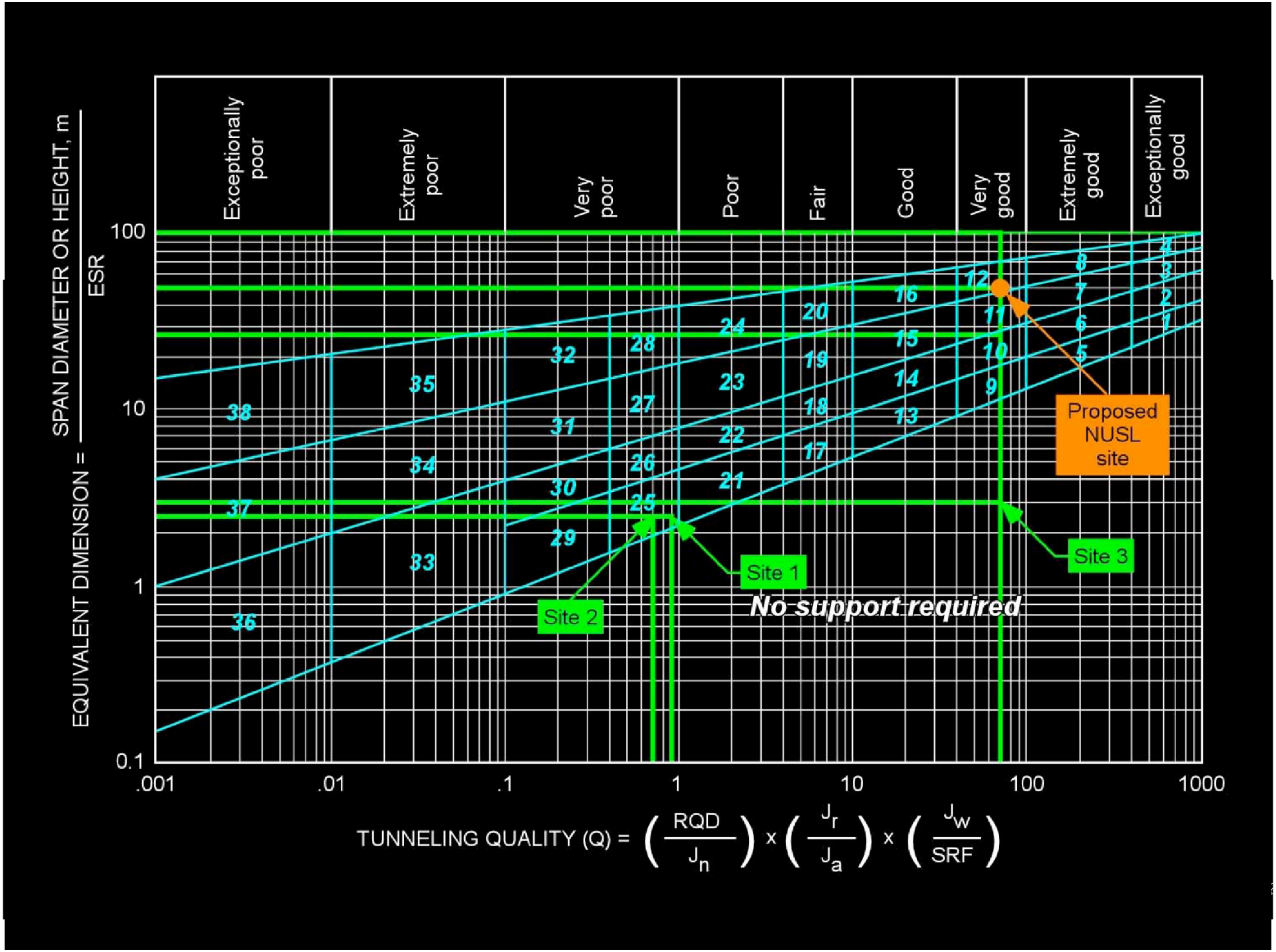
Rock stability evaluations based on actual rock samples from the proposed detector location indicate large safety factor for 100 kiloton modules.

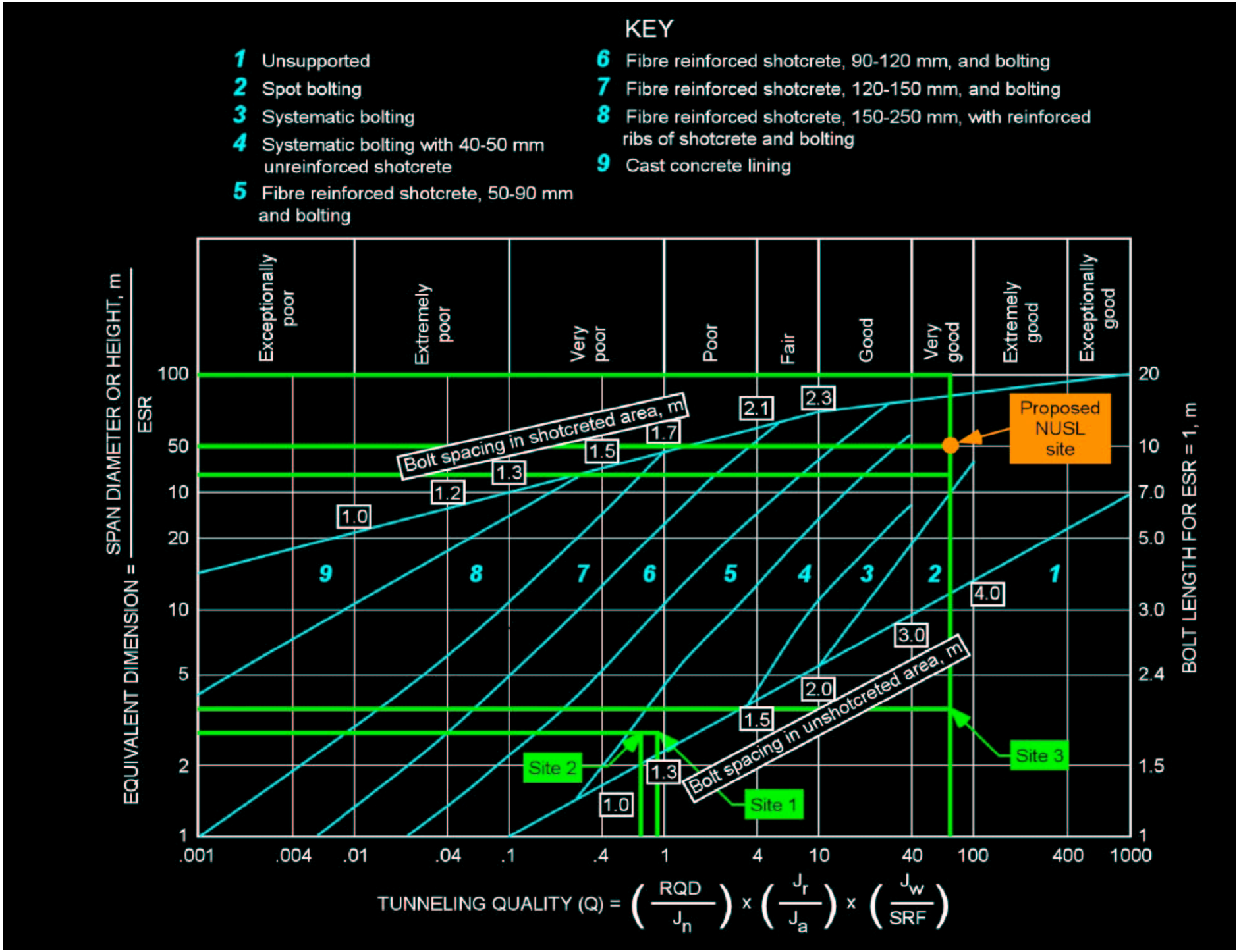


Cosmic ray flux at depth of 100 kiloton Detector = 4 muons/m^2, day

Each 100 kT module has an area of 2000 m^2 and thus 8000 muons/day

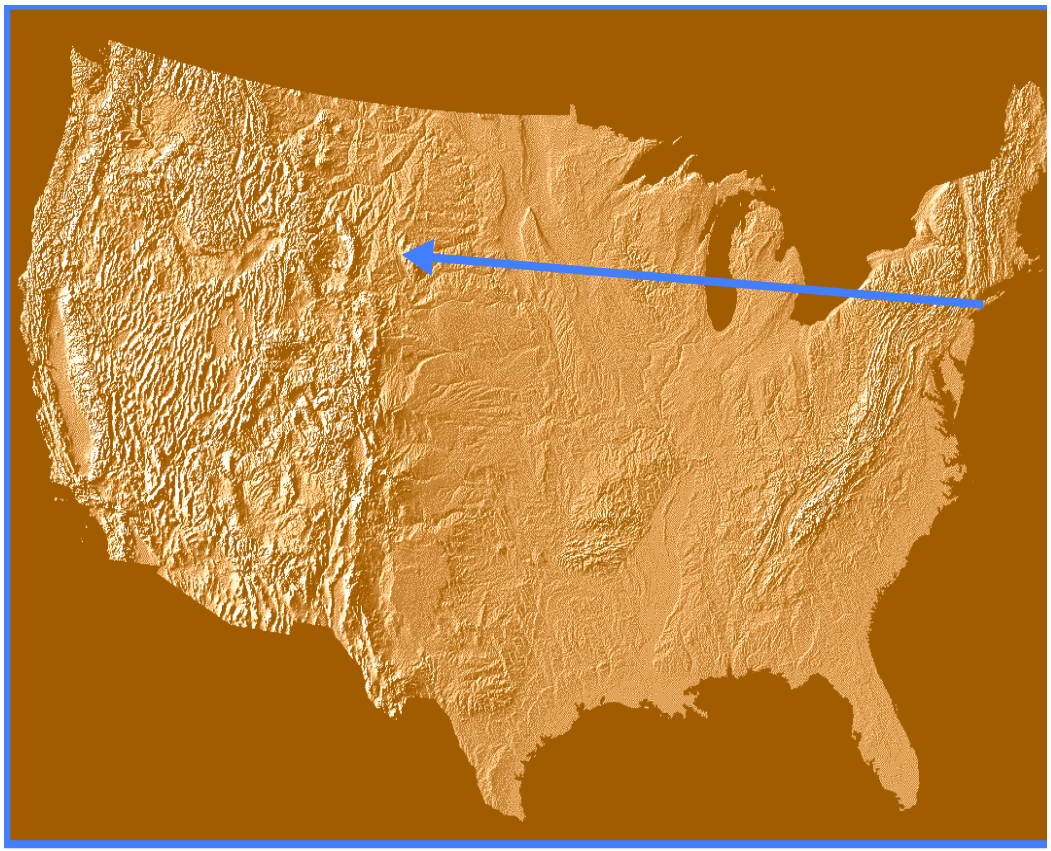
Assuming a neutrino pulse width of one microsecond/sec gives **≈ 1 cosmic ray events per year/module** during the Fermilab neutrino pulses


Exceptionally poor
Extremely poor
Very poor
Poor
Fair
Good
Very good
Extremely good
Exceptionally good
EQUIVALENT DIMENSION = SPAN DIAMETER OR HEIGHT, m / ESR
100
10
1
0.1
.001
.01
.1
1
10
100
1000
TUNNELING QUALITY (Q) = (RQD / Jn) x (Jr / Ja) x (Jw / SRF)
Proposed NUSL site
Site 1
Site 2
Site 3
No support required


KEY
1 Unsupported
2 Spot bolting
3 Systematic bolting
4 Systematic bolting with 40-50 mm unreinforced shotcrete
5 Fibre reinforced shotcrete, 50-90 mm and bolting
6 Fibre reinforced shotcrete, 90-120 mm, and bolting
7 Fibre reinforced shotcrete, 120-150 mm, and bolting
8 Fibre reinforced shotcrete, 150-250 mm, with reinforced ribs of shotcrete and bolting
9 Cast concrete lining
Exceptionally poor
Extremely poor
Very poor
Poor
Fair
Good
Very good
Extremely good
Exceptionally good
EQUIVALENT DIMENSION = SPAN DIAMETER OR HEIGHT, m / ESR
BOLT LENGTH FOR ESR = 1, m
Bolt spacing in shotcreted area, m
Bolt spacing in unshotcreted area, m
Proposed NUSL site
Site 1
Site 2
Site 3
TUNNELING QUALITY (Q) = (RQD/Jn) x (Jr/Ja) x (Jw/SRF)

Detector

Phase	Mass
1	0.5 Mtons
2	1.0 Mtons



Enhanced AGS

Phase	Power
1	0.47 Mw
2	1.0 Mw

Neutrino Beam from Brookhaven National Laboratory to the National Underground Science Laboratory

Neutrino flight path – 2540 km

Construction of a Megaton Modular Multi-Purpose Detector in the Homestake Underground Laboratory

Excavation Stability

Construction Methodology

Water Tight Liner

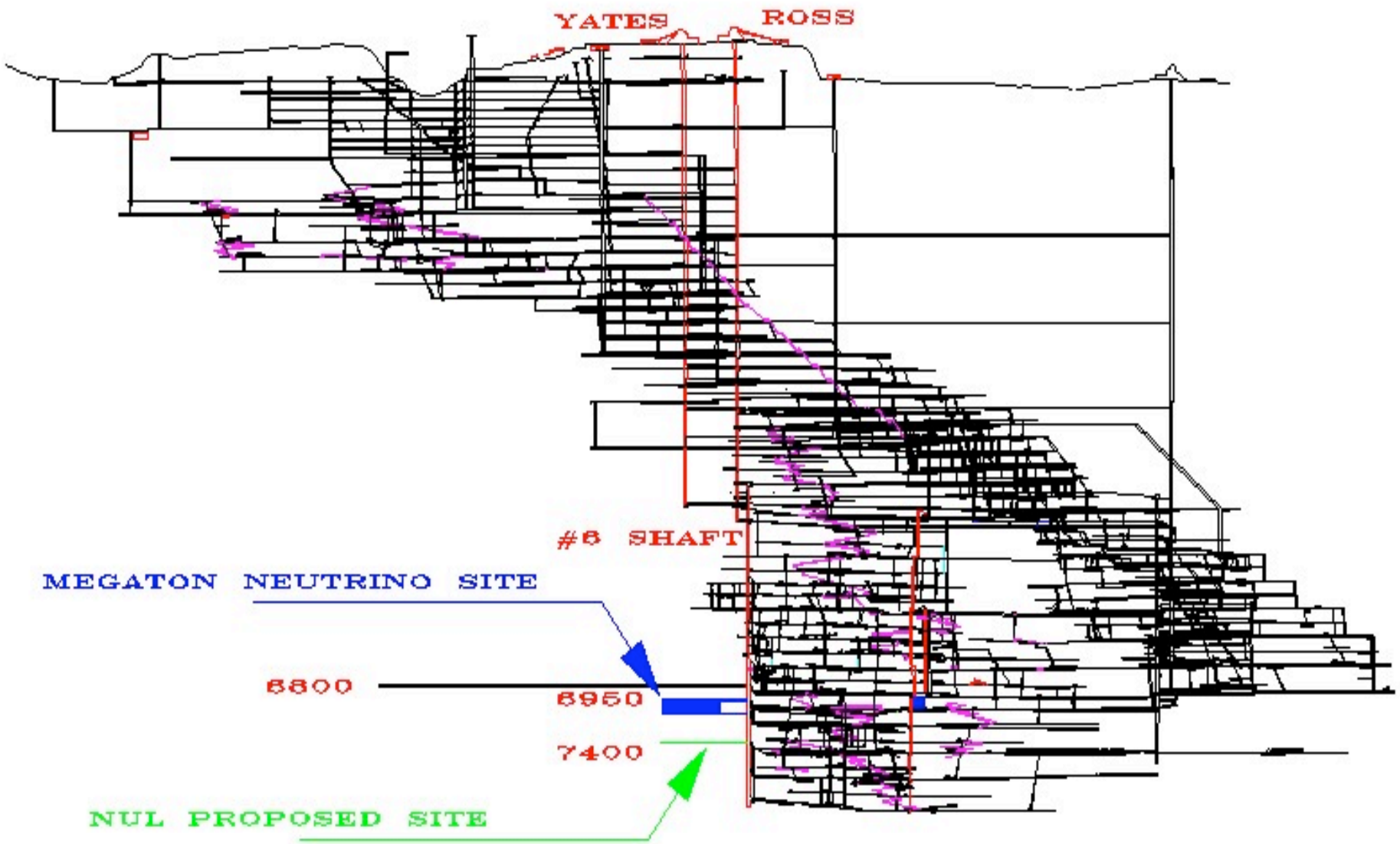
Timeline and Estimated Costs

Goal:

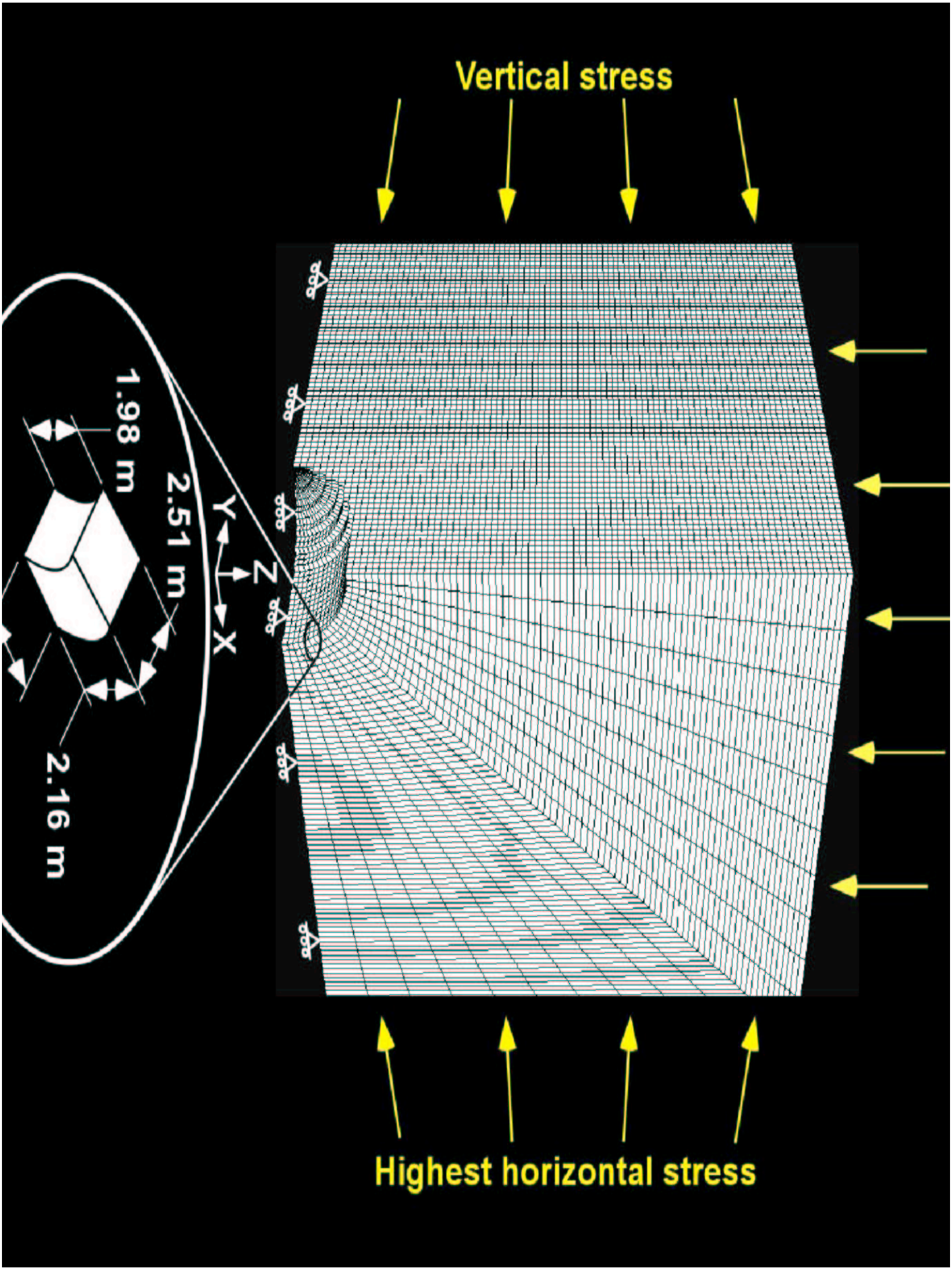
Construct a _ megaton detector in ~ 5 years.

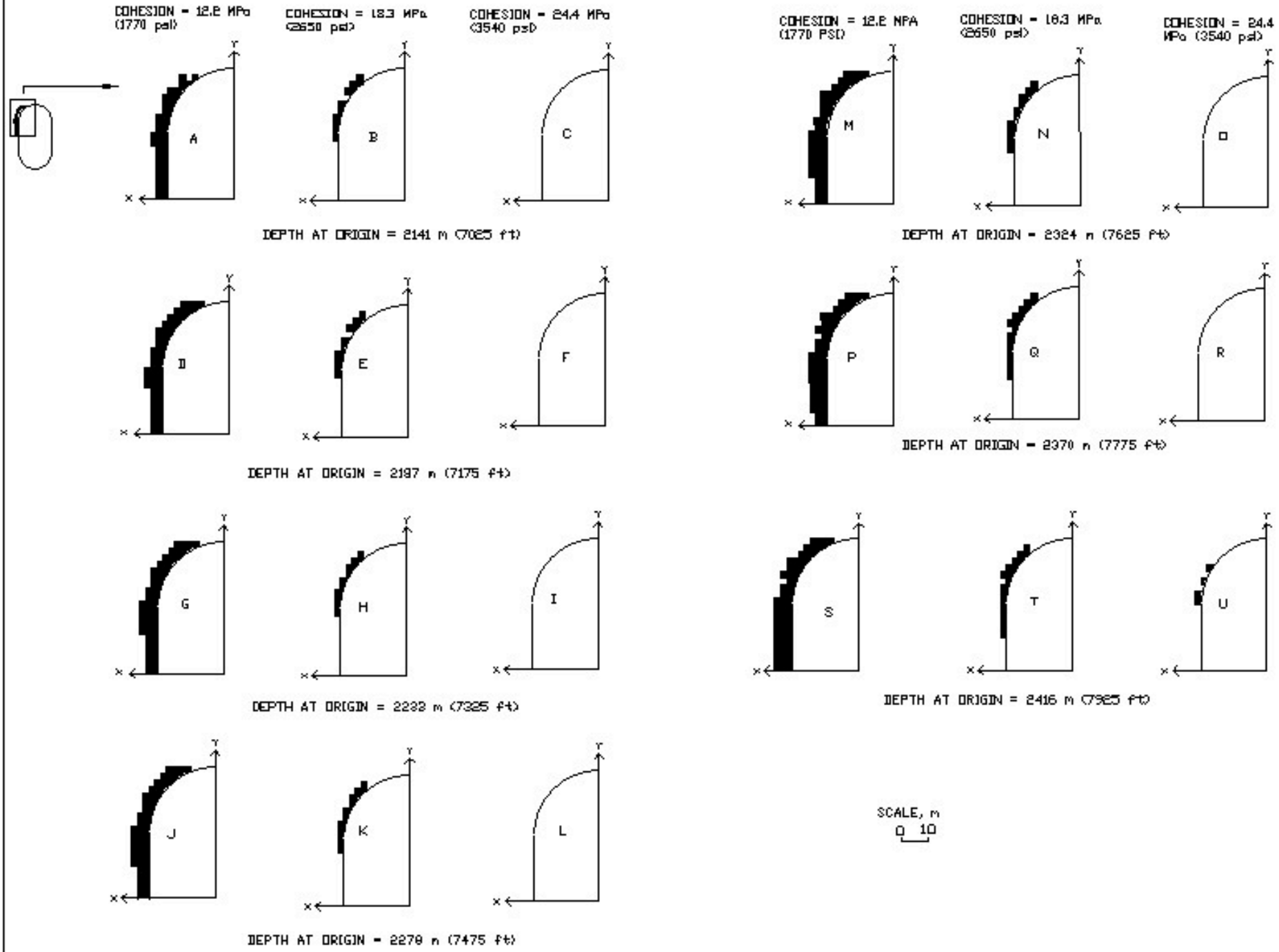
Requirements:

1) Access to great depths
2) Known rock strength parameters
3) Rock disposal plan
4) No environmental or community issues
5) Safety – construction and utilization


YATES
ROSS
#6 SHAFT
MEGATON NEUTRINO SITE
6800
6950
7400
NUL PROPOSED SITE

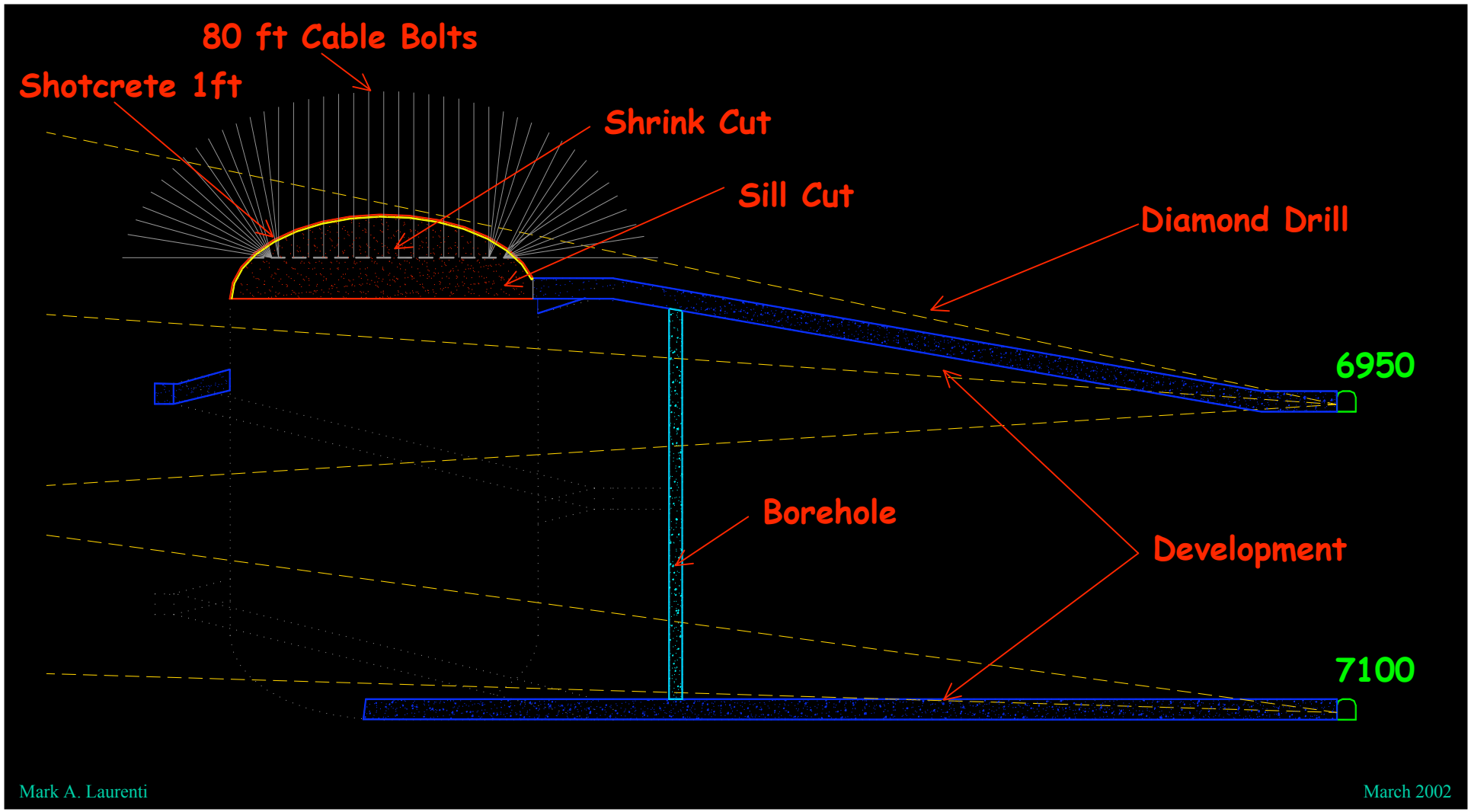

25 m
25 m


Vertical stress
1.98 m
2.51 m
2.16 m
Y
Z
X
Highest horizontal stress


COHESION = 12.8 MPa (1770 psi)
COHESION = 18.3 MPa (2650 psi)
COHESION = 24.4 MPa (3540 psi)
A
B
C
DEPTH AT ORIGIN = 2141 m (7025 ft)
COHESION = 12.8 MPA (1770 PSI)
COHESION = 18.3 MPa (2650 psi)
COHESION = 24.4 MPa (3540 psi)
M
N
O
DEPTH AT ORIGIN = 2324 m (7625 ft)
D
E
F
DEPTH AT ORIGIN = 2197 m (7175 ft)
P
Q
R
DEPTH AT ORIGIN = 2370 m (7775 ft)
G
H
I
DEPTH AT ORIGIN = 2232 m (7325 ft)
S
T
U
DEPTH AT ORIGIN = 2416 m (7925 ft)
J
K
L
DEPTH AT ORIGIN = 2279 m (7475 ft)
SCALE, m
0 10

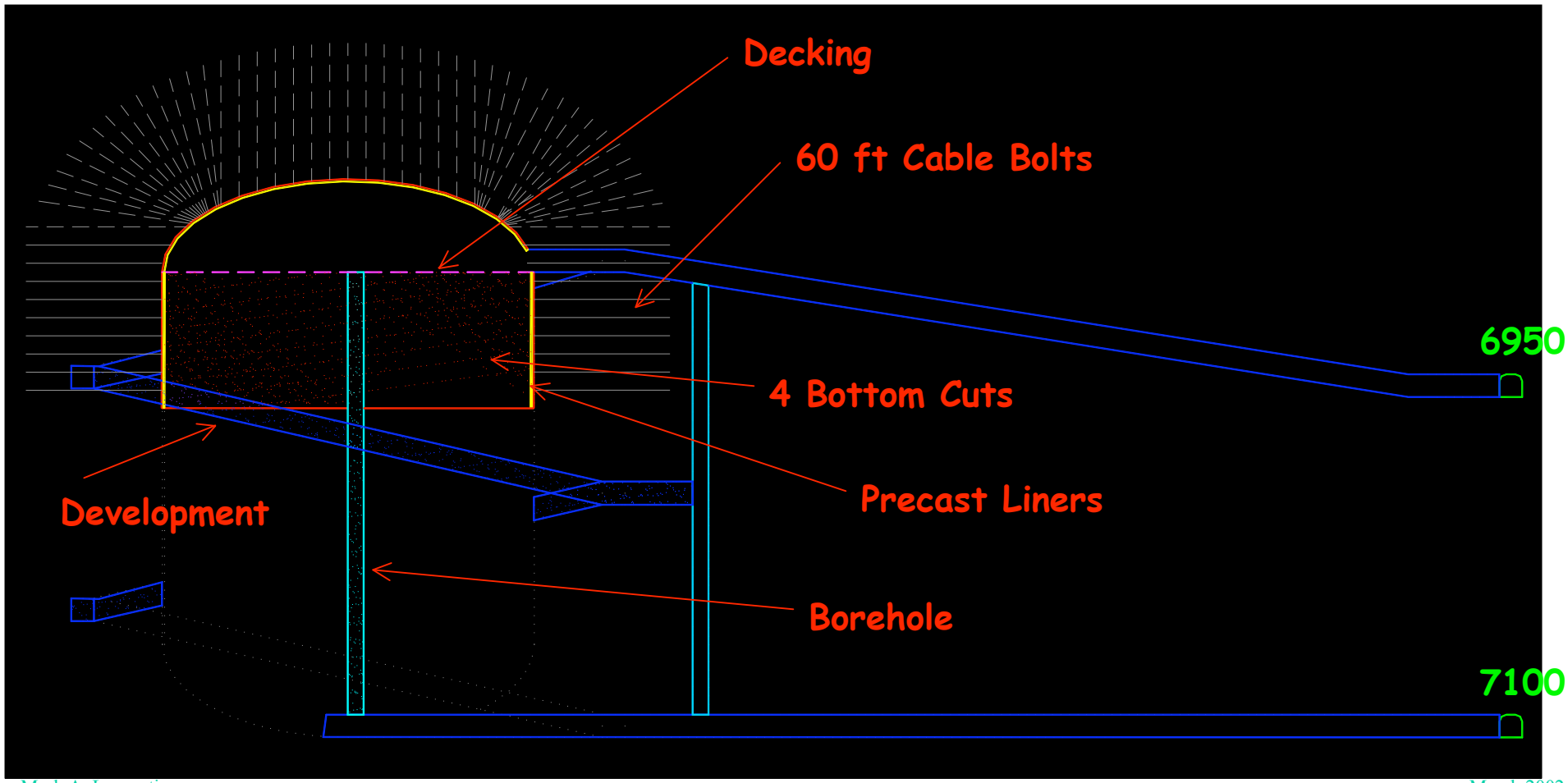
✓ Estimated Timeline

Year One

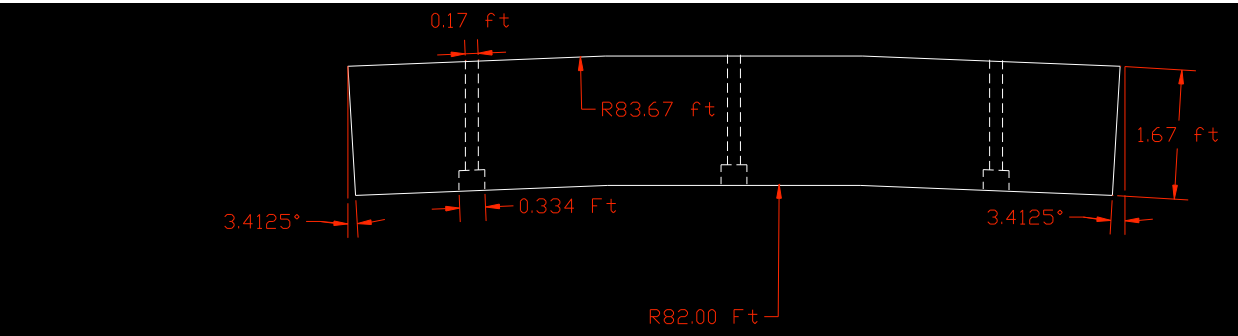


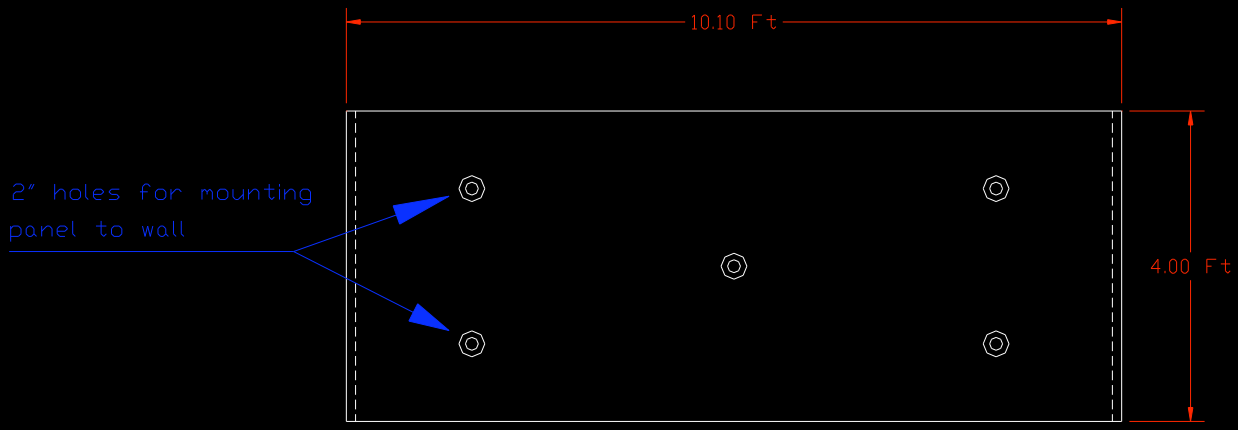
✓ Estimated Timeline

Year Two



✓ Construction Methodology



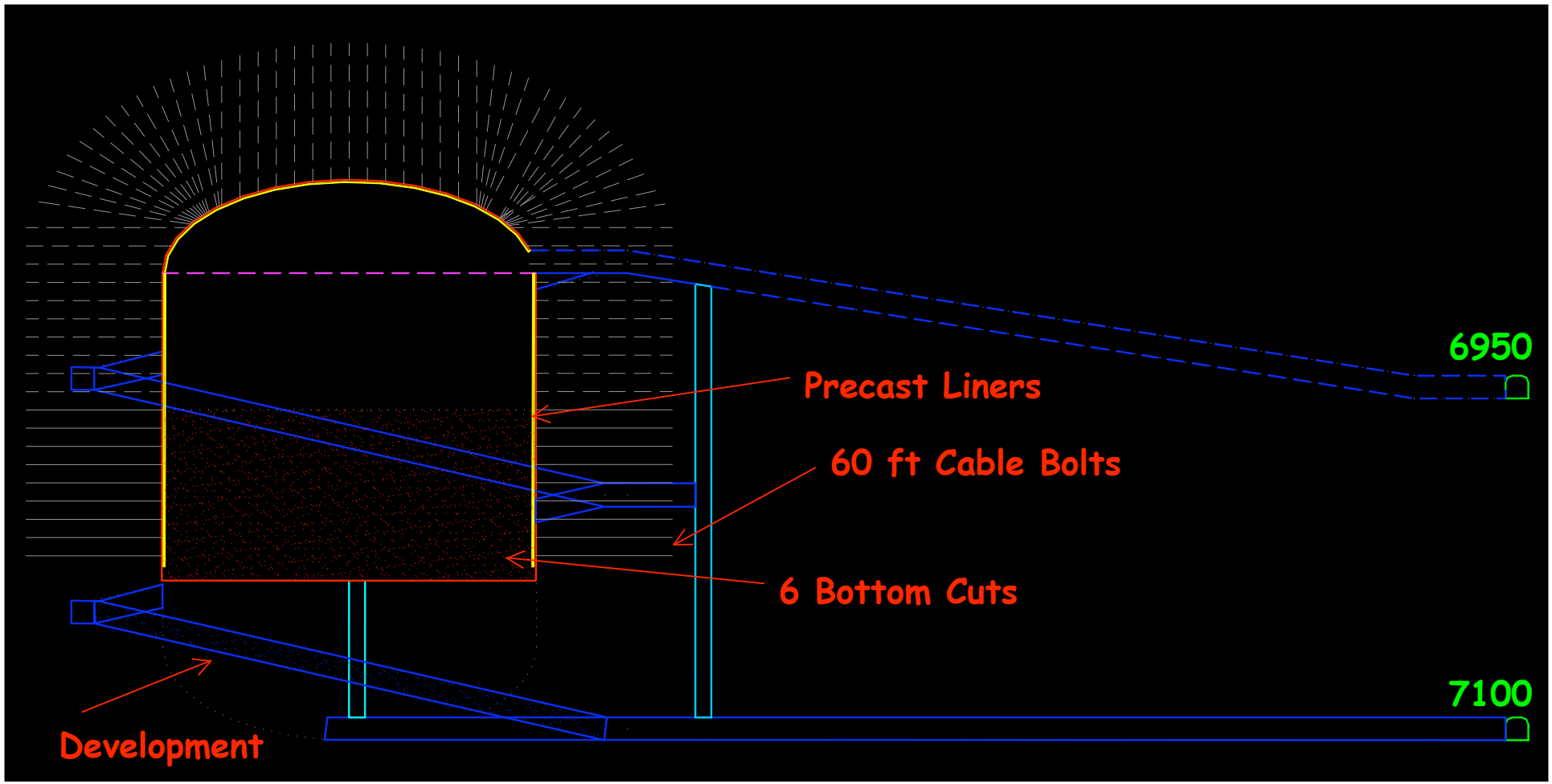


Precast Concrete Liner

10′ x 4′ x 1.667′ = 66.68 cuft
66.68cuft x 150lbs/cuft = 10,002 lbs

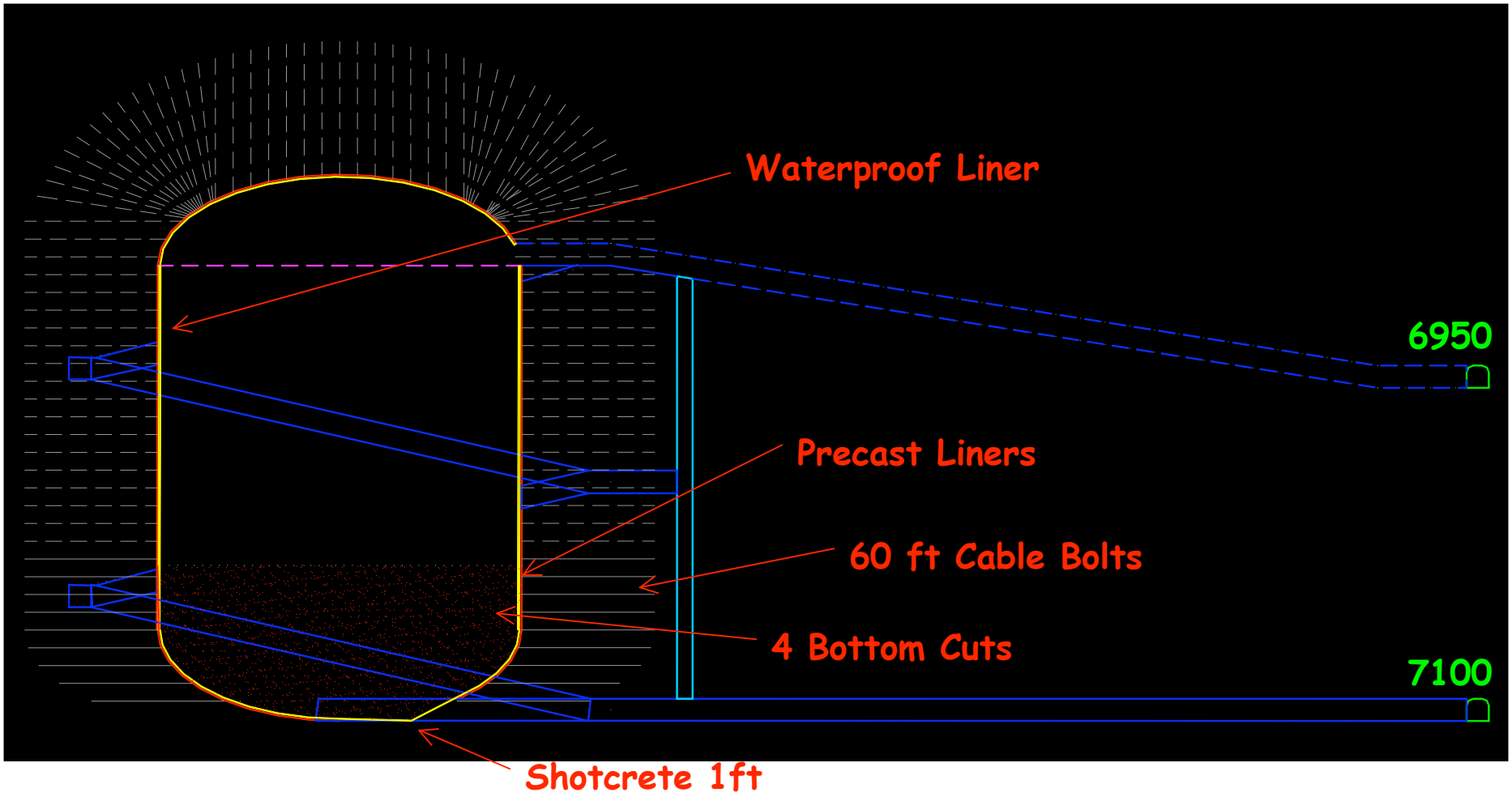
✓ Estimated Timeline

Year Three



✓ Estimated Timeline

Year Four



✓ Estimated Timeline

Total time for excavation and construction

✓ Estimated Excavation Costs ($MM)

# Of Chambers	1	3
⇨ Labor & Benefits	$ 5.51	$ 10.94
⇨ Mining & Construction		
★ Equipment Operation	$ 1.30	$ 3.89
★ Supplies	$ 4.51	$ 13.35
★ Precast Concrete Liner	$ 3.25	$ 9.75
⇨ Other (Outside Contractor)	$ 0.12	$ 0.37
⇨ 15% Contingency	$ 2.20	$ 5.74

General Parameters Used for Schedule & Cost

- ☆ Work Schedule
  3 Shifts / Day x 5 Day / Week
- ☆ Manpower -3 Supervisors
  24 Hourly Employees For One Chamber
  41 Hourly Employees For Three Simultaneous Chambers
- ☆ Hoisting Capacity For Mined Material Is 750,000 Tons / Year To The Surface From The 8000 Level
- ☆ A System Is In Place On The Surface For Handling The Mined Material Hoisted To The Surface
- ☆ Equipment For Construction Of 1 or 3 Simultaneous Chambers

4 LHD's	1 Long Hole Drills	2 Support Vehicles
2 Bolters	2 Bench Drills	
2 Face Jumbos	2 Lift Trucks	

✓ Estimated Costs

⇨ Operating Costs Not Included In Estimate

★ Equipment Purchase or Lease

✓ Cost ~ $5.00MM

✓ 5 Year Life

★ Cost of Waste Handling

★ General Operation of the Mine

★ Engineering, Geology

★ Power and water Consumption

✓ Summary

⇨ Estimated construction time for one chamber is four years

⇨ Estimated construction time for three chambers is five years

⇨ Estimated cost for one chamber is $17.0MM

⇨ Estimated cost for three chambers is $44.0MM